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EMISSIONS TRADING

This report examines whether the major U.S. emissions trading programs for air pollutants have contributed to elevated emissions concentrations in specific geographic areas, or pollution ''hot spots.'' Assessment of the actual performance of these programs shows that none has resulted in a regional shift of emissions, and all trading programs examined have led to proportionately greater emissions reductions from the larger sources. Overall, the data from the programs reviewed indicate that trading has not created geographic hot spots and, in promoting reductions at the largest plants, has smoothed out pollutant emissions instead of concentrating them.

Emissions Trading and Hot Spots: A Review of the Major Programs

BY BYRON SWIFT

I. Introduction

This report examines whether the major U.S. emissions trading programs for air pollutants have contributed to elevated emissions concentrations in specific areas, also known as pollution ''hot spots.'' Environmentalists have been concerned about the potential for emissions trading programs to create such concentrations or hot spots, as have advocates of environmental justice, who have voiced such concerns as a basis for opposing emissions trading programs.[1]

This report is the first to comprehensively examine the actual emissions data from the major emissions

[1] See, e.g., Moore, Curtis, *Marketing Failure: The Experience with Air Pollution Trading in the United States* 34 ELR 10,281 (March 2004); Johnson, Stephen: *Economics vs. Equity: Do Market-based Environmental Reforms Exacerbate Environmental Justice?* 56 Wash. & Lee L. Rev. 111 (1999).

 ISSN 0013-9211

trading programs, which primarily affect emissions of sulfur dioxide and nitrogen oxides from power plants:

- Phase I of the SO_2 Acid Rain Program (1995-1999);
- Phase II of the SO_2 Acid Rain Program (starting in 2000); and
- Ozone Transport Commission (OTC) NOx Budget Program (1999-2002).

In addition to these three major emissions cap and allowance trading programs, we also examine NOx credit trading programs in several states.

This report first examines the hot spot issue from a regional perspective, addressing the chief concern voiced at the initiation of the acid rain SO_2 trading program: whether the increased flexibility allowed by trading would result in disproportionately greater emissions from Midwestern sources, affecting sensitive ecosystems in downwind areas to the east. For the OTC NOx program we examine the data by state to determine whether there were in fact regional shifts of emissions with trading.

Secondly, we attempt to determine the effects of trading on a more local level by examining plant-level data to see whether the trading programs caused reductions homogeneously with regard to plant size, or caused disproportionate emissions reductions at plants with relatively high or low emissions.

The objective evaluation of the hot spot issue is important because emissions trading programs create the opportunity to attain pollution reduction goals at lower cost through a market-based implementation mechanism.[2] The cap-and-trade programs combine a stringent environmental standard—the cap—with a very high-integrity trading system that increases compliance options. This creates efficiency, and the major cap-and-trade programs have been credited with substantially lowering compliance costs in comparison to traditional rate-based standards.[3] By lowering costs, the programs can benefit the environment by allowing politicians to set standards that achieve even greater reductions. In addition, some authors assert that emissions cap-and-trade programs create a fundamentally better regulatory system for regional pollutants that promotes innovation, creates continuous drivers for cleaner production, and are easily enforced.[4] These benefits could be lost if inaccurate perceptions about trading systems discourage their use where appropriate.

II. Emissions Trading Systems

Emissions trading programs provide flexibility to regulated sources that must meet a common environmental standard. Trading systems allow sources that emit pollution below an allocation level or an environmental standard to sell or transfer their reductions to other sources, which may then emit above the level or standard. The flexibility afforded by trading reduces compliance costs by allowing sources that can reduce emissions more cheaply to transfer allowances or credits to other sources facing higher costs.[5] This article assesses the impact of such spatial[6] trading systems with regards to emissions concentrations or hot spots.

No assessment of emissions trading can be done without understanding its three fundamentally different forms—emissions cap and allowance trading (cap-and-trade) programs, emissions averaging programs, and project-based emissions credit programs.[7] Most of our analysis deals with the major cap-and-trade systems, which both reduce emissions and create a fundamentally different compliance system for sources than traditional technology-based rate standards. They also have a very high-integrity allowance trading system that, because of the cap, assures a decline in total emissions from affected sources. Averaging and credit systems, however, are grafted onto existing compliance systems and differ from cap-and-trade programs in many ways. These three programs differ so significantly in their environmental and economic effects that they should be considered distinct types of regulatory programs and not lumped together as trading programs.

A. Emissions Cap and Allowance Trading Programs

Most of our analysis concerns the Acid Rain Program and the Northeastern OTC NOx Program, both cap-and-trade programs. Under this approach, an overall emissions cap is established over a large region, creating a strict regulatory standard that permanently reduces emissions. All affected sources are then allocated allowances,[8] which represent their share of the total cap, and can trade allowances with each other for compliance purposes. New sources are typically not pro-

[2] See, e.g., Tietenberg, T.H., *Emissions Trading: An Exercise in Reforming Pollution Policy* (Resources for the Future, Washington, D.C., 1985); Harrison, David, *Tradable Permits for Air Pollution Control*, in INTERNATIONAL YEARBOOK OF ENVIRONMENTAL AND RESOURCE ECONOMICS 2001 (2001).

[3] See, A. Denny Ellerman et al., MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM (2000); Curtis Carlson, Dallas Burtraw, Maureen Cropper, and Karen L. Palmer, *Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?*108 Journal of Political Economy 1292 (2000).

[4] Authors point out that cap-and-trade programs guarantee emissions reductions, permanently cap emissions, create zero growth in emissions from new sources, allow greater scope for compliance through cleaner fuels and clean production technologies, increase compliance levels to virtually 100 percent, and greatly lower compliance costs. See generally, Ellerman, Denny, Paul Joskow and David Harrison, *Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases*, Pew Center on Global Climate Change, Arlington, Va. (May, 2003) [available at http://www.pewclimate.org]; Swift, Byron, *How Environmental Laws Work: An Analysis of the Utility Sector's Response to Regulation of Nitrogen Oxides and Sulfur Dioxide Under the Clean Air Act*, 14 Tulane Envtl. L.J. 309 (Summer 2001) [available at http://www.epa.gov/airmarkets/articles/index.html].

[5] See generally, U.S. EPA, *Clearing the Air: The Truth About Capping and Trading Emissions*. EPA 430F-02-009 (May 2002); Ellerman, A. Denny, David Harrison, *Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases*. Pew Center for Global Climate Change (Arlington, Va., May 2003); Haites, Erik, *An Emerging Market for the Environment: A Guide to Emissions Trading* (U.N. Environment Program, 2002) [see http://www.uccee.org/ETguide/GuideEmissionsTrading.pdf].

[6] This article refers to trading in this spatial sense of a transfer of emissions tons between different sources and examines its effects with regards to emissions concentrations. The spatial trading of allowances or credits is to be distinguished from temporal trading, such as banking, which has the effect of moving a ton of emissions from one year to another.

[7] See generally, EPA, *Three Forms of Emissions Trading*. Clean Air Markets Update, Winter 2002.

[8] Each allowance typically represents one ton of a pollutant that may be emitted in a given year.

   ISSN 0013-9211

vided with any allowances, but must obtain them from existing sources, leading to essentially a zero new source standard.[9]

The cap-and-trade approach fundamentally changes the regulatory system away from traditional end-of-pipe rate-based standards and into an overall performance system.[11] These programs have been shown to reduce the costs of compliance to half or less of the cost of traditional rate-based standards. They can also transform business compliance behavior towards a pollution prevention response and away from installing end-of-pipe controls, broaden and strengthen the context for innovation, greatly reduce administrative costs, and create almost 100 percent compliance.[10] Cap-and-trade programs also establish an extremely credible form of allowance trading based on rigorous monitoring that has high integrity because the cap prevents trading from ever leading to excess emissions.

B. Emissions Credit Trading Programs

At the other end of the spectrum are credit trading programs, which are grafted onto existing regulatory programs, such as traditional emissions rate regulations under the Clean Air Act. These are voluntary programs in which sources undertake projects that create quantifiable pollution reductions over and above their existing permitted levels or past emissions levels. The sources receive credits for these reductions, which they may then sell or transfer to other sources for compliance purposes.

Credit trading programs generally generate fewer economic and environmental benefits when compared to other trading programs. Some of the reasons are that there is no change in the underlying compliance system, fewer tons are available to be traded, and more regulatory procedures are needed, generating fewer economic gains. Also, because credit programs are used with existing permitting programs that typically do not require continuous emission monitors, they also have less reliable reporting and monitoring of emissions than cap-and-trade programs since firms can select which projects to present, credit trading systems have an inherent weakness in allowing firms to derive credit for projects that they might have done anyway, potentially increasing overall emissions. However, credit trading systems may be useful when system-wide approaches, such as cap-and-trade or averaging, are infeasible. A recent analysis provides best practices for credit programs, while noting they have lower integrity than cap-and-trade programs.[12]

C. Emissions Averaging Programs

In between these two systems are emissions averaging programs, in which a rate-based ''average,'' or standard, is established for a group of sources. Individual sources that emit below the average emissions rate can earn credits that can then be sold or transferred to sources that emit above the average rate. Averaging systems can be used either with a uniform rate standard or technology-based rate standards, although the use of a uniform standard may promote cleaner technologies.[13]

Averaging systems allow trading to take place automatically between covered sources, which allows for greater trading and thus economic gains. Although total emissions may grow over time, unlike cap-and-trade programs, all sources are included in the program, which eliminates the danger of ''gaming'' the system through self-selection of projects that exists with credit trading programs. Also, credits in averaging systems are generated through standard protocols that do not require government approval of individual projects, greatly reducing transaction costs and hence enhancing economic gains.

III. Limitations and Context of an Evaluation of Emissions Concentrations, or Hot Spots

This paper reviews the effect of existing emissions trading programs to determine if they have increased or decreased the concentration of pollution emissions. Such a study essentially evaluates and compares trading programs with other possible regulatory approaches that achieve equivalent reductions over the same sources, and as such has a number of limitations, discussed below. In particular, such a review should not be confused with one of the stringency of regulation, nor of differing needs of national versus local regulatory programs.

A. Assessing Regulatory Stringency vs. Method

The first caveat to our study is that it does not deal with the level of stringency of regulation, which is typically legislatively determined. Emissions concentrations or hot spots originate in real-world situations, such as the siting of coal-fired power plants or the use of motor vehicles, that concentrate emissions in certain areas. Only if programs are sufficiently stringent in re-

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[9] Note that several states in the OTC program did allocate a small portion of allowances to new sources.

[11] Traditional environmental regulations under the Clean Air Act have been established as technology-based rate standards measuring the concentration or percentage of a pollutant in end-of-pipe emissions. See, for example, air standards such as Reasonably Available Control Technology (RACT) for existing sources, Best Available Control Technology (BACT) for new sources, and Maximum Achievable Control Technology (MACT) for hazardous pollutants. 42 U.S.C. §§ 7502(c)(1), 7475(a)(4), 7412(g)(2)(A) (1994). Rate standards have been shown to be poor performance standards because they significantly restrict the range of technology choices available for compliance, provided limited incentives for innovation and improvement, do not encourage shifts to cleaner technology and tend to freeze innovation. See, EPA, Pub. No. EPA-101/N-91/001, PERMITTING AND COMPLIANCE POLICY: BARRIERS TO U.S. ENVIRONMENTAL TECHNOLOGY INNOVATION 39 (1991); Swift, Byron, Environmental Law Institute, *How Environmental Laws Work: An Analysis of the Utility Sector's Response to Regulation of Nitrogen Oxides and Sulfur Dioxide Under the Clean Air Act*, 14 Tulane Envtl. L.J. 309 (Summer 2001) [available at http://www.epa.gov/airmarkets/articles/index.html].

[10] For evaluations of the SO_2 program, see supra notes 3 and 4.

[12] See Environmental Law Institute, *Emission Reduction Credit Trading Systems: An Overview of Recent Results and an Assessment of Best Practices*, Environmental Law Institute (October 2002); see also Dudek, Daniel & John Palmisano, *Emissions Trading: Why Is This Thoroughbred Hobbled?*, 13 Colum. J. Envtl. L. 217 (1988).

[13] Uniform standards do so because they allow firms to meet the standard by using a cleaner technology. Technology-based rate standards on the other hand require controls regardless of how clean the technology is and so provide no incentives to install cleaner technologies. An example of a uniform standard is the fuel-neutral New Source Performance Standard for NOx. 40 C.F.R. § 60.44b.

quiring adequate pollutant reductions will emission levels in such areas actually decline.

A good example is the case of SO_2, as the building of power plants in the Midwest to use the relatively high-sulfur coals of the region led to elevated emissions levels in that region and also affected downwind (Eastern) states. Initial efforts to regulate these plants under Title I of the Clean Air Act[14] resulted primarily in the dispersion of pollution through tall stacks;[15] SO_2 emissions barely declined, falling from 17 million to 16 million tons between 1970 and 1990.[16]

The Acid Rain Program was passed in 1990 to address this situation and mandates a 50 percent reduction in SO_2 emissions from 1980 baseline levels to approximately 9 million tons.[17] While EPA data shows that the Acid Rain Program has significantly reduced sulfur deposition and sulfate concentrations in the atmosphere, it also indicates that additional reductions in sulfate deposition are still needed to assure the recovery of acidic waters and forest soils, and enhance health benefits.[18] These findings have led to the introduction of bills in Congress, as well as a proposal by EPA, that call for major additional reductions in SO_2 emissions to the 2 million to 3 million ton level.[19]

Our examination instead is of the regulatory method, in an inquiry as to whether, at a given level of stringency, the use of the emissions trading method has led to disproportional increases or decreases in emissions in certain areas that cause or exacerbate emissions concentrations.

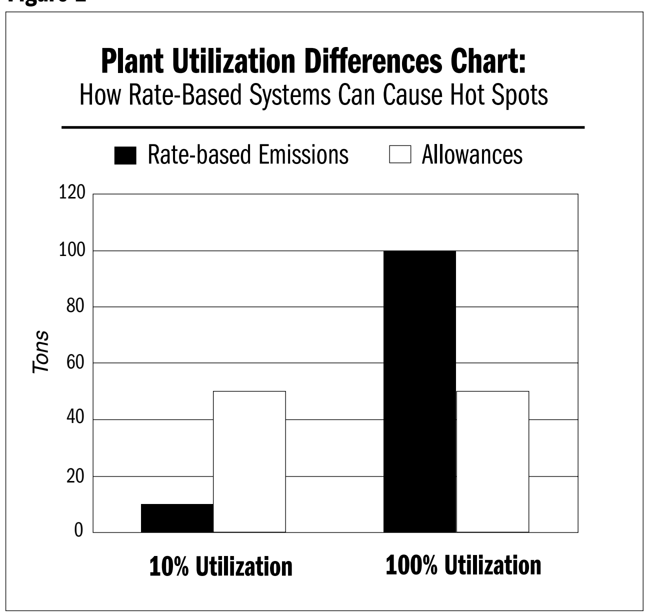
In the SO_2 example above, the issue would not be whether the reductions mandated in the Acid Rain Program were enough, but whether the program led to an uneven allocation of the tons of reduction in a way that exacerbated areas of concentration, such as the Midwest. The point is simply that we must differentiate an analysis of the effects of regulatory method—trading—from the issue of stringency and assess whether the method itself led to pollutant concentrations.

B. All Regulatory Systems Create Differentiated Emissions Levels in Plants

It is important to understand that all regulatory systems will create variable emissions responses at plants. At similar levels of overall reductions, regional or national source-specific rate standards or other regulations do not meaningfully address local emissions levels any better than trading systems. A principal reason is that rate-based regulations do not control the overall amount of pollution, which depends on plant siting, plant size, and utilization—whether a plant is operated 100 percent, 50 percent or 1 percent of the time. Therefore rate systems do not guarantee per-plant reductions. In addition, rate-based standards allow emissions to increase due to economic growth, and so over time may lead to greater overall emissions than cap-and-trade systems.

For many plants, the cap-and-trade approach, which allocates a given number of allowances to the plant, may be more likely to lead to consistent pollutant reductions than the rate-based approach. Figure 1 shows how rate-based systems can lead to greatly increased pollution at the plant level with differences in plant utilization, comparing a plant utilized at a 10 percent level to one utilized at a 100 percent level. Although the allowance allocation does not change, a rate-based regulatory system allows pollution emissions to increase greatly as plant utilization increases.

Figure 1



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C. Context of Existing Regulatory Standards

A further limitation of this study is that trading programs for NOx and SO_2 exist simultaneously with other regulatory programs for criteria pollutants. Although important, these standards would not be expected to

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[14] The federal Clean Air Act of 1970 established the first National Ambient Air Quality Standards, designed to protect health and welfare, and required states to develop "state implementation plans" (SIPs) to achieve these standards. 42 U.S.C. § 7401 et seq.

[15] For SO_2, for example, an unintended consequence of these new ambient standards was the dispersion of SO_2 through tall stacks. The EPA permitted over a dozen states to adopt SIPs allowing sources to meet the new standard by building tall stacks to disperse the SO_2 instead of reducing emissions. This practice injected SO_2 into the higher atmosphere where it remained longer, facilitating the chemical reactions that produce sulfuric acid and aggravating acid precipitation. See Vickie L. Patton, *The New Air Quality Standards, Regional Haze, and Interstate Air Pollution Transport*, 28 ENVTL. L. REP. 10,155 (1998).

[16] EPA, NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1999 EPA-454/R-01-004 (March 2001).

[17] 42 U.S.C. § 7651 et seq. (imposing a 8.95 million ton cap to be achieved by 2010).

[18] U.S. Environmental Protection Agency, ACID RAIN PROGRAM: 2002 PROGRESS REPORT at pp. 7-11. EPA-430-R-03-011 (November 2003). See also, U.S. Environmental Protection Agency, ACID RAIN PROGRAM: 2001 PROGRESS REPORT at pp. 35-37. EPA-430-R-02-009 (November 2002).

[19] Congress has acted to advance several cap-and-trade proposals for electric utilities, such as the Clear Skies Act (H.R. 999) introduced by Reps. Joe Barton (R-Texas) and Billy Tauzin (R-La.); the Clean Power Act (S. 366) introduced by Sen. Jim Jeffords (I-Vt.); and the Clean Air Planning Act of 2003 (S. 843) introduced by Sens. Tom Carper (D-Del.), Lincoln Chafee (R-R.I.), and Judd Gregg (R-N.H.). EPA announced the signing of proposed rules to reduce SO_2 emissions in a 28-state region to 2.7 million tons by 2015. U.S. EPA, *Air Quality Proposal to Deeply Cut Power Plant Emissions is Signed*, EPA Press Release (Dec. 17, 2003; 34 ER 2742, 12/19/03).

   ISSN 0013-9211

significantly affect compliance behavior in response to the cap-and-trade programs evaluated in this report.

1. State Regulation of Sources to Attain NAAQS

Prior to passage of the Acid Rain Program in Title IV, existing power plants were primarily affected by Title I of the Clean Air Act. Under this law, states develop "state implementation plans" (SIPs) [20] to attain federally-established National Ambient Air Quality Standards (NAAQS) designed to protect human health and welfare.[21] States are authorized to adopt Reasonably Achievable Control Technology (RACT) requirements on existing stationary sources to supplement more stringent federal new source standards. These standards affected plants differently for SO_2 and NOx emissions, as described below.

For SO_2, the first National Ambient Air Quality Standards were developed soon after passage of the Clean Air Act in 1970, [22] and states subsequently acted to require plants to reduce local SO_2 emissions levels. Although plants did so, many states allowed them to simply disperse the pollution through use of tall stacks, which aggravated acid precipitation, until Congress banned the practice in 1977.[23] Today, few areas are in nonattainment for SO_2,[24] and the above actions occurred well before the baseline years considered in our analysis of the SO_2 Acid Rain Program.[25] However, it is important to note that these ambient standards still exist and protect against plants emitting SO_2 at levels that would cause local air quality to exceed NAAQS.

For NOx, the first major requirement faced by plants in the OTC states was to meet RACT standards that involved the installation of low-NOx burners by 1995. Collectively, this action reduced these plants' NOx emissions by 40 percent from 1990 levels.[26] These OTC standards were roughly equivalent to the national requirement for NOx reductions for coal-burning plants imposed by the Acid Rain Program in 1996,[27] but both standards took effect before the initiation of OTC cap-and-trade program in 1999.

The cap-and-trade programs examined in this paper are in part a response to the failure of the above Title I rate-based standards to achieve significant pollutant reductions in SO_2 and NOx from power plants whose national SO_2 emissions only declined from 17 million tons to 16 million tons between 1970 and 1990, and NOx emissions only declined from 7 million to 6 million tons from 1980 to 1998.[28] The need for further overall reductions led to the imposition of cap-and-trade programs to guarantee major reductions: the Title IV SO_2 program in 1995, and the OTC NOx budget program in 1999.

2. New Source Standards

In addition to the above standards faced by existing plants, stringent federal new source standards apply to new power plants or major modifications of existing plants. These standards include New Source Performance Standards (NSPS)[29] and New Source Review standards that require the use of Best Available Control Technology (BACT) in attainment areas and Lowest Achievable Emissions Reduction (LAER) technology plus emission offsets in nonattainment areas.[30] Both BACT and LAER are stringent rate standards that are

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[20] 42 U.S.C. § 7410.

[21] The federal Clean Air Act of 1970 established the first national ambient air quality standards for SO_2, which were designed to protect health and welfare, and required states to develop "state implementation plans" (SIPs) to achieve these standards. 42 U.S.C. § 7410; 40 C.F.R. § 50.2(b). The primary air quality standards are ones "the attainment and maintenance of which . . . are requisite to protect human health," and secondary air quality standards "to protect the public welfare from any known or anticipated adverse effects." 42 U.S.C. § 7409(b). The primary standard for SO_2 was set at 0.030 parts per million (ppm), to be achieved on a calendar-year basis, and the secondary standard was 0.5 ppm, set on a three-hour basis. 40 C.F.R. §§ 50.4, 50.5. The national primary and secondary ambient air quality standard for NOx is 0.053 ppm on an annual basis, 40 C.F.R. § 50.11. However, further SO_2 and NOx reductions may be needed to meet the new primary and secondary ambient air quality standards for fine particulate matter, 40 C.F.R. § 50.7, and for ozone at 0.08 ppm. 40 C.F.R. § 50.10.

[22] 40 C.F.R. § 50.2(b) (2000). See other SO_2 standards in the note above.

[23] The EPA permitted over a dozen states to adopt SIPs allowing sources to meet the new standard by building tall stacks to disperse the SO_2 instead of reducing emissions; this practice injected SO_2 into the higher atmosphere where it facilitated the chemical reactions that produce sulfuric acid and aggravating acid precipitation. See Patton, supra note 14, at 10,162; Richard L. Revesz, *Federalism and Interstate Environmental Externalities*, 144 U. Pa. L. Rev. 2341, 2351-52 (1996); see generally, James L. Regens & Robert Rycroft, The Acid Rain Controversy 35-58 (1989) (discussing history of efforts to control acid rain). In the 1977 Clean Air Act Amendments Congress subsequently prohibited the use of tall stacks or any other dispersion technique to achieve ambient standards. 42 U.S.C. § 7423.

[24] Nonattainment areas for SO_2 only affect 24 counties and about 1 percent of the population (3.67 million people). U.S. EPA, *Sulfur Dioxide Nonattainment Areas as of June 23, 2003*. See http://www.epa.gov/oar/oaqps/greenbk/sntc.html for SO_2 nonattainment areas since Jan. 6, 2004.

[25] The baseline year used in considering the reductions achieved by the Acid Rain Program is 1980, but the data used by EPA to calculate the 1980 baseline was gathered in 1985-1987, 42 U.S.C. § 7651a(4), well after any compliance action by plants to comply with these initial Title I requirements imposed in the 1970s.

[26] See Memorandum of Understanding Among the States of the Ozone Transport Commission on Development of a Regional Strategy Concerning the Control of Stationary Source Nitrogen Oxide Emissions (Sept. 27, 1994). EPA estimates that this action reduced NOx emissions by approximately 40 percent, from a 1990 baseline level of 473,000 tons to 290,000 tons in 1995. U.S. EPA, NOx Budget Program: 1999-2002 Progress Report at 4 (2003).

[27] Nationwide rate standards based on the use of low-NOx boiler technology were imposed on coal-fired power plants in 1996 under the Acid Rain Program in Title IV of the Clean Air Act, 42 U.S.C. § 7651f.

[28] EPA, National Air Quality and Emissions Trends Report, 1999, EPA-454/R-01-004 (March 2001).

[29] 42 U.S.C. § 7411.

[30] New Source Review standards apply to new sources or major modifications of existing sources built after Aug. 7, 1977. Sources built in areas that have attained the federal ambient ozone standard set by EPA must prevent significant deterioration of air quality and install the Best Available Control Technology (BACT) for the type of plant proposed considering "energy, environmental, and economic impacts and other costs." 42 U.S.C. §§ 7475(a)(4), 7479(3). New plants in nonattainment areas must meet the even more stringent Lowest Achievable Emissions Rate (LAER) standard, which excludes considerations of cost. 42 U.S.C. § 7503(a)(2). The New Source Review standards, BACT, and LAER specify the older New Source Performance Standards only as a floor. See, e.g., 42 U.S.C. § 7479(3) (BACT), and § 7501(3) (LAER).

set on a case-by-case basis.[31] These standards have principally affected new sources and have had relatively little effect on compliance behavior of existing power plants in the programs studied.[32]

D. National/Regional vs. Local Regulation

A final caveat is that our study largely concerns programs designed to achieve national or regional levels of reductions, and not local levels. The choice between trading systems and rate-based standards is distinct from a choice between national and local regulation. Regardless of the type of regulation used to achieve national reductions, only local regulation can achieve local pollution reductions over and above national standards.

Our inquiry as to the method of regulation is however relevant to both the national or local level, as trading programs may be used to achieve these local goals as well. For example in Houston, a local cap-and-trade program was initiated in 2002 that will ultimately achieve a 90 percent reduction in NOx in the Houston-Galveston area.[33] Clearly, a national program aimed at achieving a 50 percent reduction will only partially assist Houston in this effort and added local regulation is needed. However, our study would be relevant to both situations, in clarifying whether trading would be expected to lead to emissions concentrations within whatever area is defined as the area subject to regulation.

IV. Results of Trading Programs

This paper now examines the actual emission data from four major emissions trading programs to determine whether they resulted in shifts in emissions among regions or plants that led to concentrating local emissions levels. We evaluate four major programs:

- Phase I of the SO_2 Acid Rain Program (1995-1999);
- Phase II of the SO_2 Acid Rain Program (2000 and 2001);
- Ozone Transport Commission NOx Budget Program (1999-2002); and
- NOx Discrete Emission Reduction credit trading programs in several states.

V. SO_2 Acid Rain Program

The nation's largest emissions cap and allowance trading program is the SO_2 cap-and-trade program under Title IV of the Clean Air Act.[34] The program was designed to reduce SO_2 emissions from electric utilities by 10 million tons from 1980 levels. Its passage in 1990 broke a 10-year legislative impasse to address the primary cause of acid rain.[35] The program combines an SO_2 emissions cap set to reach 8.95 million tons by 2010 with a flexible implementation mechanism that lets sources trade emissions allowances to achieve efficiency in reaching the cap.

This program has been implemented in two phases. Phase I commenced in 1995 and required the 265 largest, highest-emitting power units to make significant initial emissions reductions.[36] Starting in 2000, Phase II requires all plants above 25 megawatts in capacity (2,300 units in all) to comply with a nationwide emissions cap set at 8.95 million tons of SO_2.[37] These reduction levels were achieved, although the opportunity for banking allowances meant that many sources achieved early reductions by emitting below their allocated levels during Phase I, and have used the stored allowances to emit slightly above their allocated levels during the initial years of Phase II (see Figure 2).

The Title IV program has been called one of the most effective emissions reduction programs, principally because it achieves significant and permanent reductions at very low compliance costs. Compliance costs for full Phase II implementation are estimated at $1.2 billion per year, well below initial estimates that ranged from $3 billion to 7 billion.[38] The low cost is attributed to the flexibility afforded by both the cap approach and trading mechanism. However, the program has achieved a number of other notable results as well: virtually 100 percent compliance; high monitoring quality; low transaction cost to business; and very low administrative costs to government.[39]

A. Lack of Regional Emissions Shifts

Possibly the most important concern in the hot spot debate has been whether trading programs would lead to regional shifts in emissions. This concern was especially acute for the SO_2 Acid Rain Program, where it

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[31] New Source Review establishes an emissions rate standard set by regulators on a case-by-case basis based on the specific plant and power-generation technology. 42 U.S.C. § 7479.

[32] After 1978, new source standards for SO_2 essentially requires scrubbing, (see 40 C.F.R. § 60.43a and the standards in notes 29 & 30, supra), but only 35 units (other than new units) installed scrubbers from 1978 to 1994, when plants started to install scrubbers for compliance with the Title IV cap-and-trade program. U.S. ENERGY INFORMATION AGENCY, PUB. NO. EIA-0348(99)12. FLUE GAS DESULFURIZATION (FGD) CAPACITY IN OPERATION AT U.S. ELECTRIC UTILITY PLANTS AS OF DECEMBER 1999, 2 ELEC. POWER ANNUAL, table 30 (October 2000). This failure of existing sources to reduce pollution promoted a series of lawsuits by states and EPA in 1999 against a number of major utility companies, only some of which have been settled.

[33] The Mass Emissions Cap and Trade Program (MECTP) has been established by the Texas Commission on Environmental Quality for certain stationary sources of nitrogen oxides (NOx) emissions in the Houston-Galveston nonattainment area (HGA). The initial cap was implemented Jan. 1, 2002, with mandatory reductions increasing over time until achieving the final cap by Jan. 1, 2007. 30 Tex. Admin. Code § 101.351. See http://www.emissionstrading.com/tx_facts.htm on the World Wide Web.

[34] This title was promulgated in the Clean Air Act Amendments of 1990, 42 U.S.C. § 7651 et seq. See generally A. Denny Ellerman et al., MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM (2000) and Byron Swift, Environmental Law Institute, *How Environmental Laws Work: An Analysis of the Utility Sector's Response to Regulation of Nitrogen Oxides and Sulfur Dioxide Under the Clean Air Act*, 14 TULANE ENVTL. L.J. 309 (Summer 2001) [available at http://www.epa.gov/airmarkets/articles/index.html on the Web].

[35] Richard Cohen, WASHINGTON AT WORK, BACK ROOMS AND CLEAN AIR (1990) (discussing congressional debates); Ian M. Torrens et al., *The 1990 Clean Air Act Amendments: Overview, Utility Industry Responses, and Strategic Implications*, 17 ANN. REV. ENERGY & ENV'T 211, 213 (1992).

[36] 42 U.S.C. § 7651c.

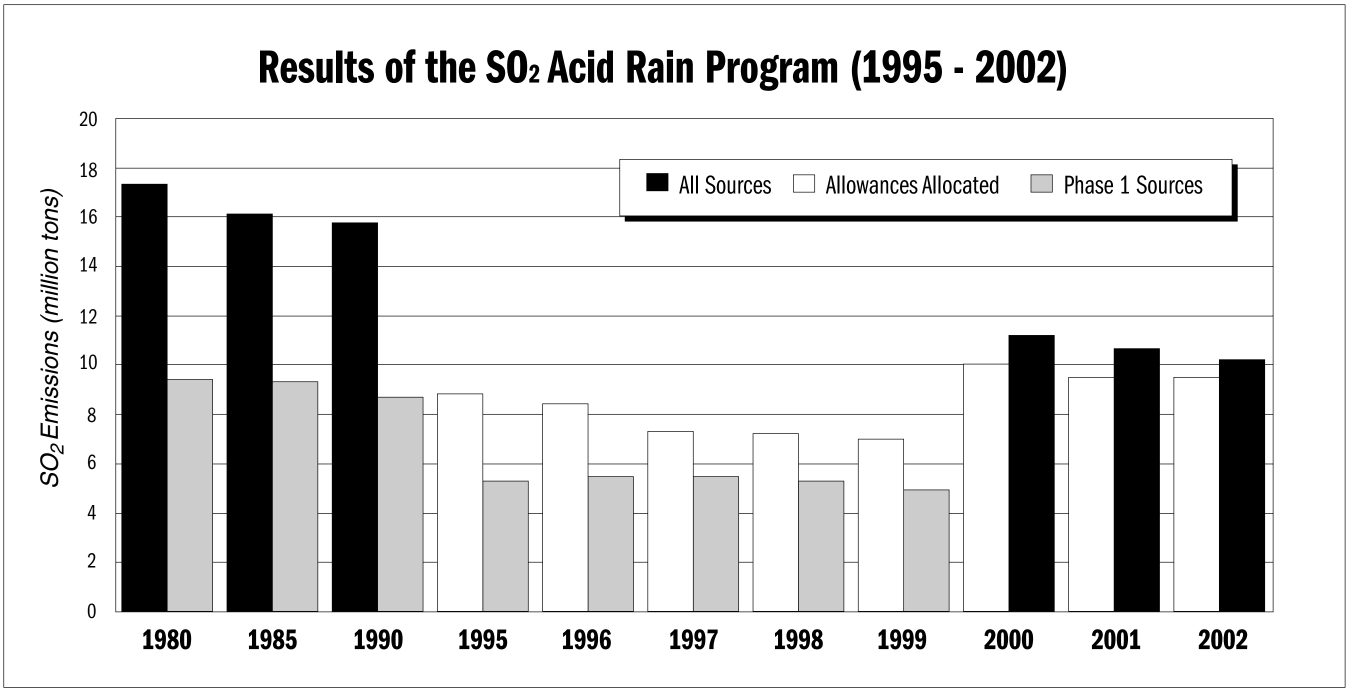
[37] 42 U.S.C. § 7651d.

[38] Ellerman, Denny, *Lessons from Phase 2 Compliance with the U.S. Acid Rain Program*, MIT CEEPR Working Paper WP-2003-009 at 4 (Cambridge, MA, May 2003) [see http://mit.edu/ceepr/www/workingpapers.htm on the Web].

[39] See EPA, Acid Rain Program Compliance Reports 1995-2002; references in note 34, supra; Brian Mclean, *Evolution of Marketable Permits: The U.S. Experience with Sulfur Dioxide Allowance Trading*, 8 INT'L J. ENVTL. & POLLUTION 19 (1997).

   ISSN 0013-9211

Figure 2



Source: EPA, Acid Rain Program: Compliance Reports [1995-2002]; and EPA, Acid Rain Program: Emissions Scorecard [1995-2002]. Both series are available at http://www.epa.gov/airmarkets/emissions/index.html#reports on the Web.

A BNA Graphic/en425g02

was feared that trading could increase emissions from Midwestern sources, whose emissions had traditionally caused significant harm in sensitive ecosystems in the Northeast states and Canada.[40] This section examines the data to see whether regional shifts have in fact occurred.

1. Results of Phase I of the Acid Rain Program

Figure 3 shows the actual results from Phase I of the Acid Rain Program by region, for all units that participated in all five years of Phase I.[41] Three numbers are illustrated for each region: the first bar shows 1980 baseline emissions levels;[42] the second, the allowances allocated on an annualized basis; and the last, actual emissions on an annualized basis. The regions are composed of the Midwest (8 states), Southeast (8 states), and Northeast (14 states).[43] The data show that during Phase I, sources collectively emitted well below the baseline levels, as required by the cap, but also below their allocation levels.

Note that there are two ways of determining the effect of the cap-and-trade program on shifts in emissions levels. The most important is the comparison of baseline emissions levels (the left bar) with actual emissions levels during the program (the right bar). This incorporates both elements of a cap-and-trade program—the reductions caused by the cap itself and any changes caused by the trading program. A second view of only the effect of trading would compare the allowance allocation (the middle bar) with actual emissions. However, it is important to view cap-and-trade systems as a complete system, as the imposition of the cap also strongly affects emissions results.

a. Greatest Reduction in the Midwest. The most important finding in this Phase I data is extremely good news: by far the greatest reductions from baseline emissions in terms of both tonnage and percentage reductions took place in the Midwest, the region with the highest emissions. Midwestern sources reduced SO_2 emissions by 55 percent from baseline levels, compared to only 45 percent in other regions (see Figure 4).

Two factors may help to explain this result. The first is that the formula for allocating allowances was itself a

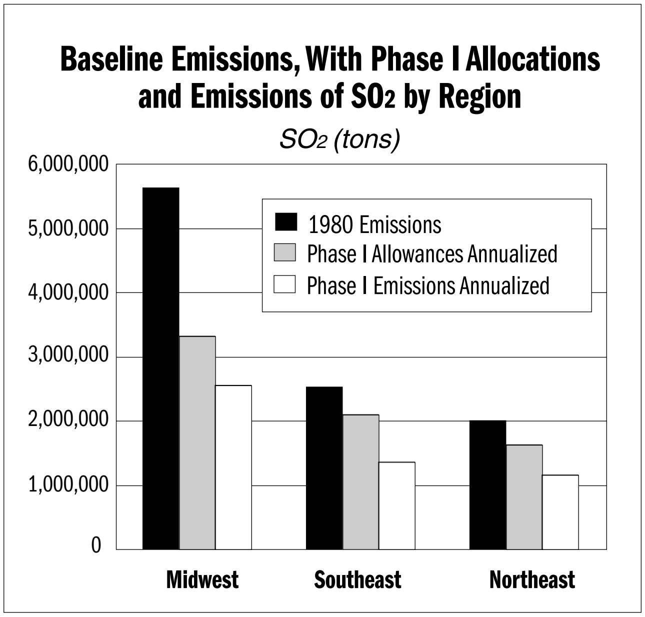
[40] Acid precipitation damage has been most pronounced in the northern tier and northeastern United States and Canada because the forests and lakes in these areas are more sensitive to acidic deposition. National Acid Precipitation Assessment Program, 1990 Integrated Assessment Report (1991); see also James L. Regens & Robert Rycroft, The Acid Rain Controversy 35-58 (1989).

[41] These units included the 265 "big and dirty" units that were required by Congress to participate in Phase I (Table A plants) and those other units, called substitution and compensation units, that participated in all five years of Phase I. Title IV allowed firms to select which plants would participate in Phase I as substitution units each year, and so the data does not include emissions for those substitution units that participated in fewer than 5 years.

[42] The intent of Congress in creating Title IV was to effect a 10-million-ton reduction in SO_2 from 1980 levels. However, monitoring data in 1980 was not adequate to fairly judge the actual emissions of each source, and so individual source monitoring data was used from the years 1985-1987, and then scaled to equal 1980 emissions.

[43] The Midwestern states are Illinois, Ohio, Indiana, Iowa, Michigan, Minnesota, Missouri, and Wisconsin; the Southeastern states are Alabama, Kentucky, Georgia, Florida, Mississippi, North Carolina, South Carolina and Tennessee; and the Northeastern states are Connecticut, the District of Columbia, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia. All sources participating in Phase I are covered within these regions except for one unit in Kansas.

Figure 3



Source: EPA, Acid Rain Program: Compliance Reports [1995-1999]; and EPA, Acid Rain Program: Emissions Scorecard [1995-1999]. Both series are available at http://www.epa.gov/airmarkets/emissions/index.html#reports on the Web.

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Figure 4

Title IV Phase I Emissions Reductions From 1980 Baseline*

Region	Total Tons Reduced	Percent Change From Baseline
Midwest	3,079,034	-55%
Southeast	1,168,720	-46%
Northeast	854,173	-43%
Total	**5,101,927**	**-50%**

*Units participating all five years only.

A BNA Graphic/en425g04

The data exclude 2 units in Kansas that were the only western units in Phase I. The tons of reduction show only those tons allocated to units (including bonus allowances).

Source: EPA, Acid Rain Program: Compliance Reports [1995-1999]; and EPA, Acid Rain Program: Emissions Scorecard [1995-1999]. Both series are available at http://www.epa.gov/airmarkets/emissions/index.html#reports on the Web.

factor in reducing emissions concentrations proportionately greater in high emissions areas such as the Midwest. In Phase I, allowances were allocated to units on the basis of 2.5 lb. SO_2 per million Btu (mmBtu) multiplied by their 1980 baseline *utilization*. This meant that the dirtier plants with high baseline emissions rates had to reduce emissions significantly more to reach their allowance allocation than cleaner sources did. The allocation method disproportionately affected sources burning the high-sulfur coals in the Midwest, leading to greater incentives to reduce emissions in this region. The second reason is that large plants reduced emissions the most,[44] which also led to greater reductions in the Midwest, as that region has relatively more large plants. The result is that by far the greatest reduction occurred in the region with the greatest emissions, thereby contributing to cooling rather than creating hot spots.

b. Consistency Among Regions in the Use of Trading. The second evident feature of the Phase I data is that the three major regions are quite similar in terms of the use of trading mechanisms: sources in each region reduced emissions by a roughly similar percent below allocations and banked most of these saved allowances.[45]

Since emissions in each region were consistently below the total amount allocated, there is also little to no discernible effect regarding the spatial shift of emissions due to trading. The only thing that can be said is that sources in the Southeast banked slightly more allowances than other regions (35 percent, as opposed to 29 percent in the Northeast and 23 percent in the Midwest). A contributing factor to this result was the ''BUBA'' strategy of the major utility in the region, the Southern Company, to ''Bank, Use and Buy Allowances;'' the company banked almost 2 million tons of allowances.[46] However, an examination of the Phase II results shows that the extra allowances banked in the Southeast were not traded to other regions, but primarily were used to allow sources in the Southeast to emit slightly above their allowance allocations in Phase II.

2. Results of Phase II of the Acid Rain Program

Phase II of the Acid Rain Program commenced in 2000 and covers all 2,300 units above 25 MW, not just the ''big dirty'' plants included in Phase I. In Phase II, allowance allocations were lowered to reach the final cap level of 8.95 million tons.[47] Figure 5 shows the results for 2001, the second year of implementation of Phase II.[48] The regions comprise the Midwest (8 states), Southeast (10 states), Northeast (14 states), and West (17 states).[49] Note that sources are emitting slightly

[44] See Part IV.B infra.

[45] Banking refers to emitting below allowance allocations in order to save allowances to use in future years. As shown, most firms in Phase I chose to bank allowances to use in Phase II, when they would face a much lower emissions cap. In all, nearly three-quarters of the allowances freed up for emissions trading in the first three years of Phase I were banked for later use. Ellerman 2000 at Section 6.6. Although the banked allowances are expected to be used in the future, banking causes early reductions, which has positive environmental consequences in reducing sulfur deposition earlier.

[46] See Gary R. Hart, *Southern Company's BUBA Strategy in the SO_2 Allowance Market*, in EMISSIONS TRADING 204, 205 (Richard F. Kosobud ed., 2000); see generally, Swift, 2001 at 335 and Fig. 2-5.

[47] 42 U.S.C. § 7651d.

[48] 2001 was selected because it is the intermediate year of implementation of Phase II (all three years of which are very similar in their emissions characteristics), and also lacked the 400,000 bonus allowances allocated in 2000.

[49] The Midwestern states are Illinois, Ohio, Indiana, Iowa, Michigan, Minnesota, Missouri, and Wisconsin; the Southeastern states are Alabama, Arkansas, Kentucky, Georgia, Florida, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee; the Northeastern states are Connecticut, the District of Columbia, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia; and the Western

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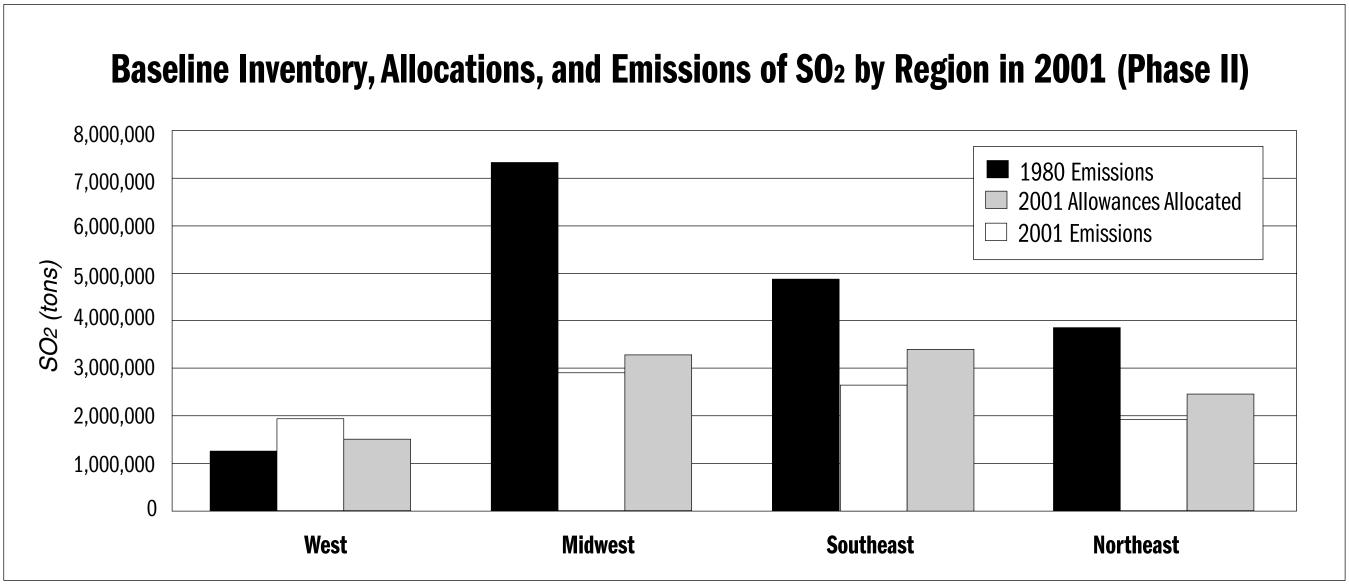
above their allocation levels as they use up the bank of allowances saved through early reductions in Phase I.

Figure 5



Source: EPA, The EPA Acid Rain Program 2001 Progress Report. Pub. No. EPA-430/R-02-009 (November 2002); EPA, Acid Rain Program: 2001 Emissions Scorecard (2002). A BNA Graphic/en425g05

Again, the news for hot spots is very good. In Phase II, as in Phase I, by far the greatest reductions occurred in the Midwest, the most polluted region, and all three major regions—Midwest, Southeast, and Northeast—behaved similarly in the use of trading.

Note that the relatively few plants in the West behaved quite differently from eastern plants. Western plants tend to be newer and cleaner than Eastern plants, with ready access to low-sulfur Powder River Basin coal, and so had low baseline emissions levels. As a consequence, the allowance allocation to Western plants was actually above their baseline emission levels. Their actual emissions in 2001 were slightly below their allocation level, but above their baseline level.[50]

a. Consistency Among Regions in Use of Trading. The first major point with regard to hot spots is that all three major regions achieved similar results in the use of trading mechanisms, if one compares the level of 2001 allowance allocations with the level of 2001 emissions. However, because sources are using up the bank of allowances accumulated by early reductions made in Phase I, sources in each of these regions emitted slightly over their allocated level in 2001 (although well below their baseline emissions level).

Again, the only slight difference in regions is in the Southeast, where sources had slightly more emissions in Phase II in comparison to their allocation level than the other regions. However, this is simply the converse of their behavior in Phase I, when Southeast sources had the greatest amount of early reductions (see Figure 3). The slightly greater reduction in Phase I and slightly greater emissions in Phase II in the Southeast therefore reflect banking behavior by these same sources, and not any spatial flow of allowances to or from other regions.

b. Significantly Greater Total Reductions Occurred in the Midwest. The second point relevant to hot spots is very significant: if one looks at the environmental result, in comparing 1980 baseline levels with 2001 emissions, considerably greater reductions occurred in the Midwest than in other regions. Sources in the eight-state Midwest region achieved a 55 percent reduction from baseline levels and contributed 60 percent of the total tons of abatement, far exceeding other regions, as shown in Figure 6.

The reasons for the greater reductions in the Midwest appear to be the same as in Phase I. A significant cause is that disproportionately large emissions reductions are made at the largest plants, as described in part B below. Many Midwestern plants are among the dirtiest sources (those with the highest baseline emissions), including 10 out of the highest 17 plants and 15 out of the next 34 highest plants. This over-representation of large plants accounts for 47 percent of the greater than average reductions in the Midwest.[51]

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states are all those west of and including the Great Plains, except Texas.

[50] Since the allocation methodology assigned plants allowances based on baseline emissions of 1.2 lb SO_2 per million Btu (mmBtu), very low-emitting plants such as many in the West received more allowances than baseline emissions, leading to the emissions characteristics shown in Figure 5.

[51] The discussion in subpart B shows that higher-polluting plants tend to reduce emissions more than others in the SO_2 trading program, which would help to explain the greater reductions in the Midwest, as many Midwestern plants are over-represented in the third and fourth quartiles, the plants with the highest baseline emissions shown in Figure 9. A detailed analysis shows that Midwestern plants constitute 42 percent of total baseline emissions, but constitute 59 percent of the largest plants in the fourth quartile (10 out of the 17 largest plants, representing 2,574,681 out of the 4,394,151 tons of 1980 baseline emissions in this quartile), and 44 percent of the third quartile (15 of the next largest 34 plants, representing 1,911,019 out of 4,359,691 tons of 1980 baseline emissions in the next quartile); however Midwestern plants are under-represented in the smaller plants, making up only 37 percent of the third quartile and 29 percent of the quartile with the lowest emitters. If Midwestern sources were to have behaved according to the national average, their baseline emissions of

Figure 6

Phase II SO_2 Emissions Reductions From Baseline Levels, by Region in 2001

Region	Total Tons Reduced	Percent Change From Baseline
West (17 states)	(+239,430)	+23%
Midwest (8 states)	4,046,904	-55%
Southeast (10 states)	1,466,343	-30%
Northeast (13 states)	1,404,920	-37%
Total	**6,678,737**	**-39%**

Source: EPA, The EPA Acid Rain Program 2001 Progress Report [Pub. No. EPA-430/R-02-009 (November 2002); EPA, Acid Rain Program: 2001 Emissions Scorecard (2002). A BNA Graphic/en425g06

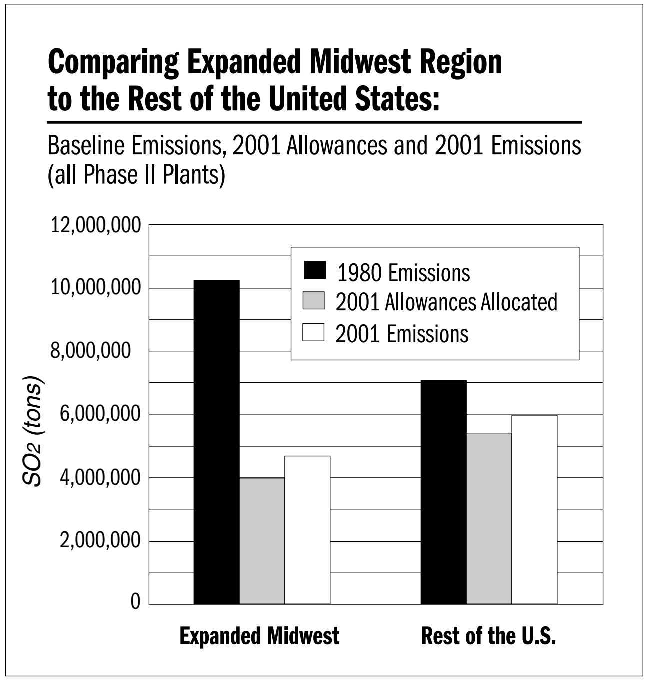
A second factor is that Title IV's allowance allocation method disproportionately reduced allowance allocations to the dirtiest sources—shown by the difference between baseline emissions and allocation levels in Figure 5. Both of these factors indicate that the large reduction made in the Midwest is not a coincidence, but a predictable aspect of the SO^2 allowance trading program.

c. Reductions Even Greater in an Expanded Midwest Region. The finding of a disproportionately large amount of emissions reduction in the Midwest is reinforced if one slightly expands the Midwest to include Kentucky, Tennessee, and West Virginia. These states behaved quite similarly to Midwestern ones and altogether achieved a 54 percent reduction—compared to only a 16 percent reduction in the rest of the United States. Together, the 11 states in this expanded Midwest region constitute 60 percent of baseline emissions, but contributed a very high 80 percent of all tons of abatement from 1980 emissions levels. Again, this is extremely good news for hot spots—a disproportionately high portion of reductions came from the most polluted region (see Figure 7).

d. Counterfactual Emissions Also Show Greater Midwestern Reductions. In the above analysis, we compare actual Phase II emissions with baseline emissions to determine the contribution of Midwestern sources. We note that a similar conclusion is reached if one compares baseline emissions to an estimate of the ''counterfactual emissions'' that would have occurred in 2001 without Title IV. The Center for Energy and Environmental Policy Research of the Massachusetts Institute of Technology (MIT) calculated such counterfactual emissions and determined that the great majority, 77

7,326,537 tons should have been reduced by only 44 percent to 4.1 million tons; this over-representation among large sources alone would predict that Midwest sources should reduce emissions to approximately 3.7 million tons. Actually, Midwestern sources emitted 3.28 million tons in 2001, so the over-representation of large sources explains almost half (47 percent) of this difference between predicted (4.1 million) and actual (3.28 million) emissions. The lower allowance allocation likely also played a causative role.

Figure 7



Source: EPA, The EPA Acid Rain Program 2001 Progress Report [Pub. No. EPA-430/R-02-009 (November 2002); EPA, Acid Rain Program: 2001 Emissions Scorecard (2002). A BNA Graphic/en425g07

percent, of abatement has been achieved at the older, high-emitting plants located in Midwestern states.[52]

We conclude therefore that the Phase II cap-and-trade program led to emissions reduction exactly where they are needed most to address health and environmental problems—in the Midwest—where sources achieved three times the reductions from 1980 baseline emissions as sources in the rest of the country.

B. Analysis of Plant-Level Emissions

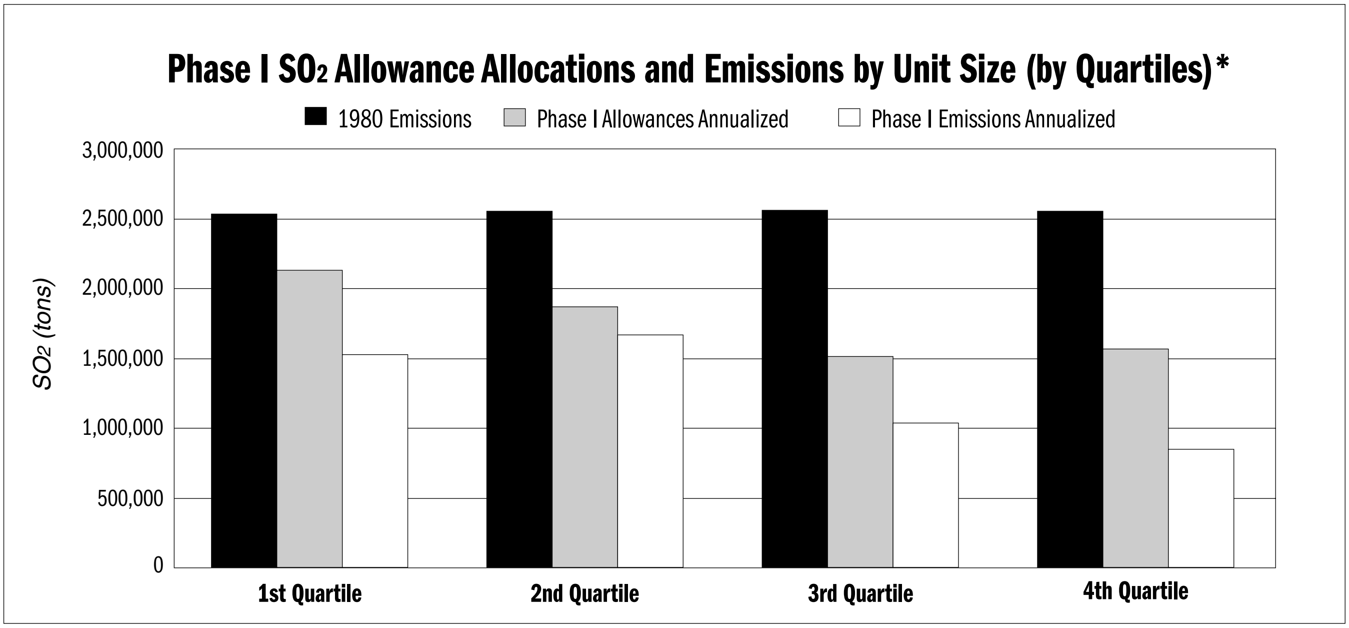
A different way to evaluate the environmental consequences of a cap-and-trade approach is to assess where emissions reductions have taken place on a plant level. Did cap-and-trade programs reduce emissions evenly across plants, or were there disproportionate reductions in plants with relatively high or low emissions levels? Reductions at higher-emitting plants would have a beneficial tendency to cool, and not create, hot spots.

The results from all the examined trading programs show strongly that disproportionately greater reductions were made at the higher-emitting plants. A plant-level analysis therefore shows that trading programs result in the dispersion, not the concentration of emissions.

Figures 8 and 9 show emission data by size of the source (unit or plant) for Phases I and II of the Acid Rain Program. Sources are grouped into four quartiles according to plant size, with each quartile representing sources with 25 percent of baseline emissions. The fourth quartile on the right side represents a few large (highest-emitting) sources, whereas the first quartile on the far left represents a large number of small

[52] Ellerman, Denny, *Lessons from Phase II Compliance with the Acid Rain Program* at 4. MIT CEEPR Working Paper 2003-009 (Cambridge, MA 2003) [available at http://web.mit.edu/ceepr/www/2003-009.pdf on the Web].

Figure 8

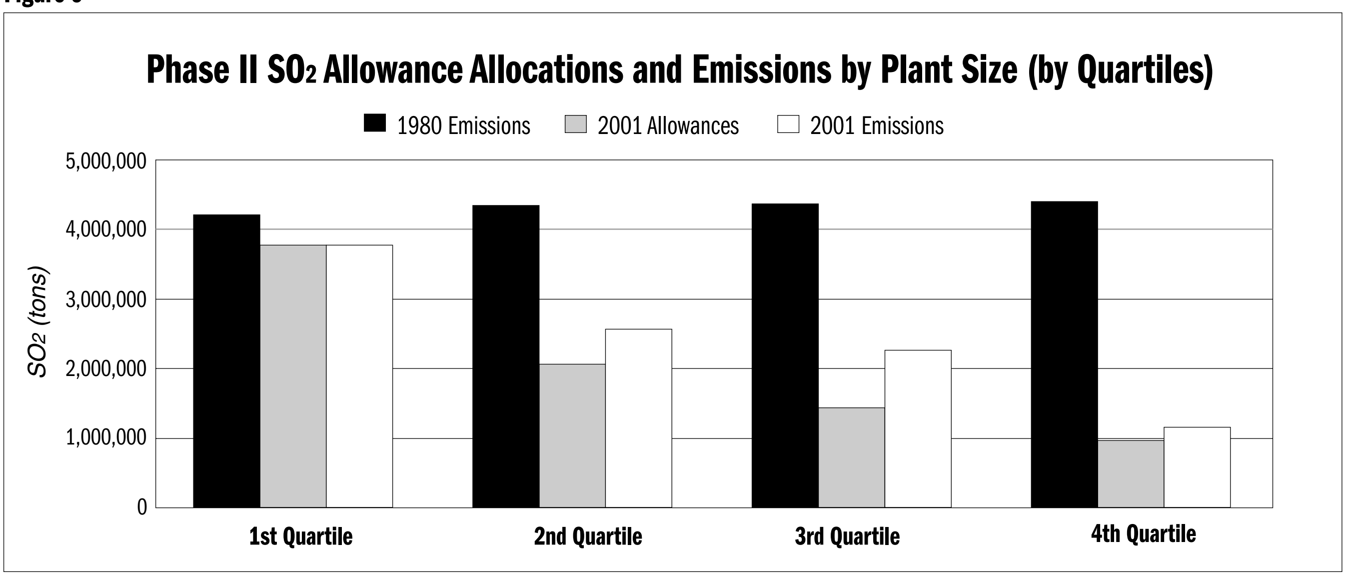


*This table was sorted by units based on the amount of their baseline emissions; with each quartile representing sources responsible for approximately 2.5 million tons of SO_2 in 1980. The 24 units (at approximately 11 plants) with the largest baseline emissions comprise the "large dirty" units in the fourth quartile; the next largest 42 units comprise the third quartile; there are 69 units in the third quartile; and the remaining 235 units are in the fourth quartile representing the units with the smallest baseline emissions level.

A BNA Graphic/en425g08

Source: EPA, Acid Rain Program: Compliance Reports [1995-1999]; and EPA, Acid Rain Program: Emissions Scorecard [1995-1999]. Both series are available at http://www.epa.gov/airmarkets/emissions/index.html#reports on the Web.

Figure 9



Source: EPA, The EPA Acid Rain Program 2001 Progress Report. Pub. No. EPA-430/R-02-009 (November 2002); EPA, Acid Rain Program: 2001 Emissions Scorecard (2002).

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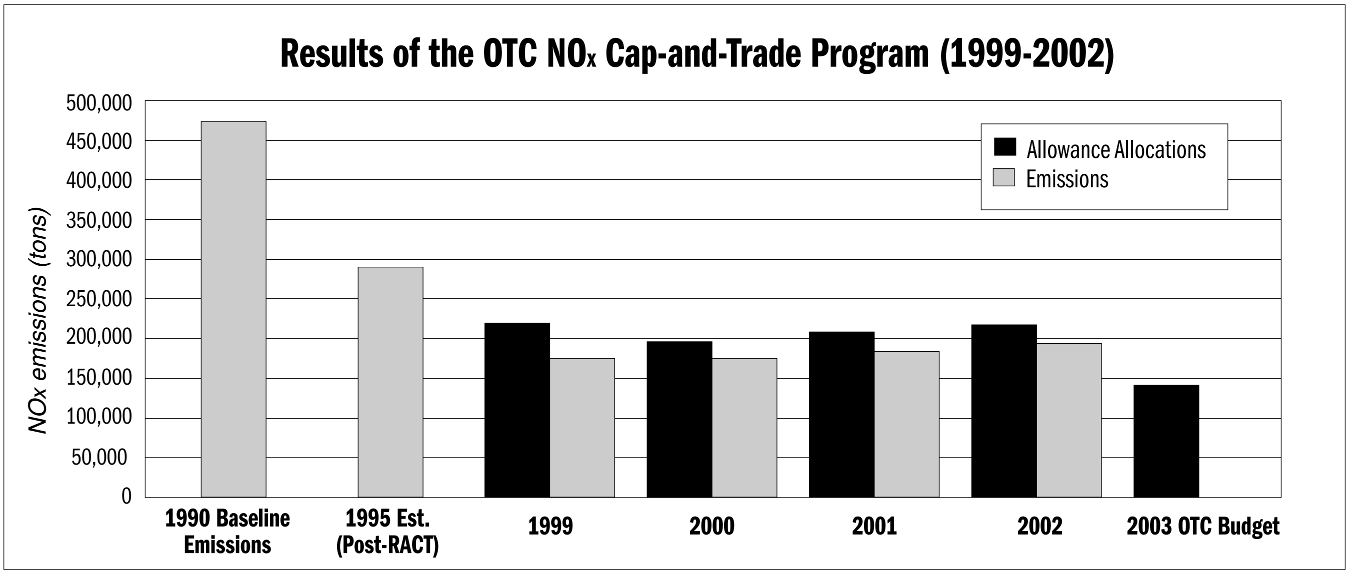
sources.[53] The data reveals that the larger sources achieved significantly greater emissions reductions in both Phase I and II, and especially in Phase II.

[53] We choose to sort by size of baseline emissions (as opposed to another factor such as capacity) because the most significant environmental goal is the total reduction of pollution from baseline emissions to present emissions. The quartiles sort sources by size into four groups with roughly equivalent total baseline emissions, such that the relatively ''large dirty'' sources (with the highest baseline emissions levels) make up the fourth quartile, the next largest in terms of their baseline emissions make up the third quartile, and many sources with relatively low baseline emissions levels comprise the first quartile. This allows us to determine whether reductions are made at the few ''large dirty'' source in the fourth quartile, or the

Figure 10



Source: EPA, OTC NOx Budget Program Compliance Reports [1999 - 2002]; available at http://www.epa.gov/airmarkets/cmprpt/index.html on the Web. A BNA Graphic/en425g10

For Phase I, Figure 8 shows that the largest units in the fourth quartile reduced emissions the most, by 67 percent below 1980 baseline levels, compared to 59 percent for the third quartile, 35 percent for the second, and 40 percent for the fourth quartile containing the smallest sources.

The finding of disproportionately greater reductions from the largest sources is even more striking in Phase II, as shown in Figure 9. The data show that significantly greater reductions have been achieved as average plant size grows larger. The fourth quartile, representing the 17 Phase II plants with the highest baseline emissions, reduced their emissions by 73 percent from baseline levels, compared to a 48 percent reduction by the next 34 plants in the second quartile, 41 percent from 71 plants in the third, and only 10 percent from the remaining 887 smallest plants.[54]

These data confirm a general prediction about cap-and-trade programs, which is that they will tend to create incentives for the dirtiest plants to clean up the most, where the economies of scale are the greatest. Capital investment in the form of process equipment or control equipment, such as scrubbers, would be predicted to be made at large plants where the most reductions can be achieve for the investment, and where the per-ton cost of reductions will be cheapest. The actual evidence confirms this theory, and shows convincingly that, if anything, trading may be expected to cool hot spots and not create them.

VI. OTC NOx Budget Program

The second major U.S. cap-and-trade program has been implemented by the Ozone Transport Commission, a coalition of 12 Northeastern states with a unified program to reduce NOx emissions from electricity generators and industrial sources during the summer ozone season.[55] Phase I commenced in 1994 and imposed rate-based standards similar to the NOx rate standards imposed under Title IV.[56] Phase II of the program imposed a seasonal emissions cap and allowance trading program for NOx to achieve additional reductions, which covered nine of the 12 states from 1999 to 2002. In 2003, Phase III reduced the emissions cap level further, as the OTC program becomes part of a larger NOx ‘‘SIP call’’ trading program for Eastern states.[57]

Although the OTC budget program is a cap-and-trade program similar to the Title IV SO_2 program, it has a number of different features. Instead of allocating allowances to each source, it allocated allowances to each state in accordance with that state's share of the regional budget. The states in-turn allocated the allowances to sources within the state. Another feature was that the OTC states established an Inner, Outer, and Northern zone for the purpose of setting reduction targets, but because trading was allowed on a 1:1 basis between all zones, roughly equivalent emissions reductions were achieved in all zones.[58] Although banking is allowed, a mechanism called flow control potentially reduces the amount of banked allowances that can be used in future years.[59]

progressively larger number of smaller sources in the following quartiles.

[54] Note that the analysis for Phase I is for units, and that for Phase II is for plants (which may contain several units), although the findings are expected to be similar in either case. Since Phase II has many more sources, we show data at the plant level, as we find the most environmentally relevant concern is the level of emissions at the site or plant level.

[55] See Memorandum of Understanding Among the States of the Ozone Transport Commission on Development of a Regional Strategy Concerning the Control of Stationary Source Nitrogen Oxide Emissions (Sept. 27, 1994), available at http://www.otcair.org on the Web.

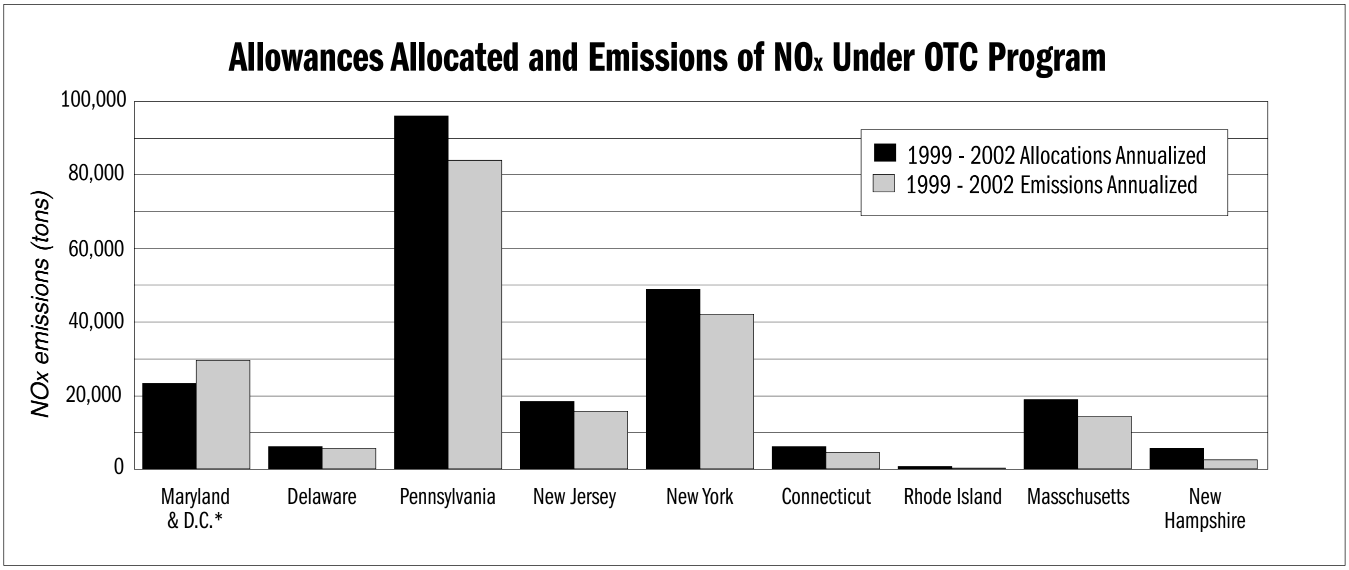
[56] In Phase I of the OTC program, states required sources to install Reasonably Available Control Technology (RACT) by 1994, a standard roughly equivalent to the Title IV NOx standards based on low-NOx burner technology, 42 U.S.C. § 7651f, but applying almost one year earlier.

[57] EPA, NOx Budget Program: 1999-2002 Progress Report at 4-5 (2003), available at http://www.epa.gov/airmarkets/otc/otcreport.pdf on the Web.

[58] Id. at 7.

[59] See generally EPA, OTC NOx Budget Program: 2002 Compliance Report 2 (2003), available at http://www.epa.gov/airmarkets/cmprpt/otc02/index.html on the Web.

Figure 11



*Note that most Maryland and DC sources did not participate in the program until 2001, and all sources did not fully participate until 2002, due to a law suit. The data in the table show only 2002 allocations and emissions.

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Source: EPA OTC Budget Program Compliance Reports; (Maryland data for 2002 only).

The OTC NOx cap-and-trade program, which reduced emissions by 60 percent from 1990 baseline levels, and by 35 percent from estimated RACT levels achieved under Phase I.[60] Surprisingly, sources have lowered overall emissions by more than the allowance allocation in each of the four ozone seasons (1999-2002), as shown in Figure 10. Also, as discussed below, emissions were below allowance allocation levels in all states but Maryland, whose entry into the program was delayed due to a lawsuit. Also, analyses by EPA and independent researchers show that the cap-and-trade program has been effective in reducing both average and peak emissions levels by a similar proportion, alleviating a concern that the OTC program might not reduce short-term peak NOx emissions.[61]

We examine the emissions data to determine the effect of trading on emissions concentrations in two different ways. First, we look at the data by state to determine if shifts in emissions occurred regionally, and then by Inner and Outer zones to see if there were any east-to-west emissions shifts. As with the SO_2 program, the data show very little regional shifting of emissions.

A. Analysis of Emissions Shifting by State

Viewed on a state-by-state basis, very little emissions shifting can be observed, as emissions reductions in most states, especially the large ones, were quite consistent, averaging 11 percent below their allocated levels. However, slightly greater than average emissions reductions occurred in New England (due in part to an unplanned outage of a New Hampshire unit) and slightly less than average in Maryland. The result in Maryland, however, was affected by a lawsuit that delayed the entry of most sources, which created uncertainty and may have allowed sources to take advantage of the lower-than-expected price of allowances. This situation, though anomalous, created a small emissions shift equivalent to about 3 percent to 4 percent of total allocations.[62] However, this shift was small and in a climatically neutral north-to-south direction, and so should not affect transport or hot spots (see Figure 11).

B. Viewing Emissions by Inner and Outer Zones

Another way to judge whether spatial emission shifts occurred under the OTC NOx program is to view whether there were ‘‘wrong-way’’ shifts in emissions that moved emissions upwind, or in an east-to-west direction. This can be readily determined because the OTC program was divided into an Inner Zone comprising the heavily populated corridor from Washington, D.C., to Boston, almost all of which is classified as an ozone nonattainment area, and a more westerly Outer Zone.[63]

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[60] EPA, NOx BUDGET PROGRAM: 1999-2002 PROGRESS REPORT at 6-7 (2003). Sources received allowance allocations representing either a 55 percent or 65 percent reduction from 1990 baseline levels, depending on whether they were located in the Outer or Inner zones. In addition, 24,635 bonus allowances were provided, which slightly increased allocations.

[61] Id. at 8. See also Farrell, Alexander E., *Temporal Hotspots in Emissions Trading Programs: Evidence from the Ozone Transport Commission NOx Budget.* Presented at an EPA conference, *Market Mechanisms and Incentives: Applications to Environmental Policy* (Washington, D.C., May 1-2, 2003).

[62] Due to the lawsuit, Maryland sources did not participate fully in the program until 2002, when they emitted 6,290 tons over their allocation level. In contrast, sources in New England emitted an average of 9,000 tons below their allocated levels. Data from EPA, *2002 NOx Budget Program Compliance Report* at 2 (June 25, 2003). Therefore, if one compares the lower emissions in New England and the higher emissions in Maryland to the average emissions rate achieved in all states, the result is that 7,500 tons of emissions were ‘‘shifted’’ annually from New England states to Maryland due to the flexibility allowed by trading. Note however that a portion of these net reductions will never be emitted, due to flow control that reduces the value of banked tons.

[63] See Ozone Transport Commission, *NOx Budget Program: 1999-2002 Progress Report* at 5 (EPA, Washington, D.C., 2003) [available at http://www.epa.gov/airmarkets/otc/

The data show that from implementation of the program resulted in comparable reductions in both zones—a 59 percent reduction in the Outer Zone and a 58 percent reduction in the Inner Zone (see Figure 12).[64] Although the reduction levels were almost identical to the extent there was a one-percent shift in emissions, in terms of wind direction it was a ''right-way'' shift in emissions from western to eastern sources, reducing transport of NOx. A contrary view is that reductions in nonattainment areas are 1 percent less than reduction in more westerly attainment areas, which is not desirable. Either way, the shift in emissions was slight, showing again that trading programs have achieved consistency in emissions results.

C. Daily Emissions Levels

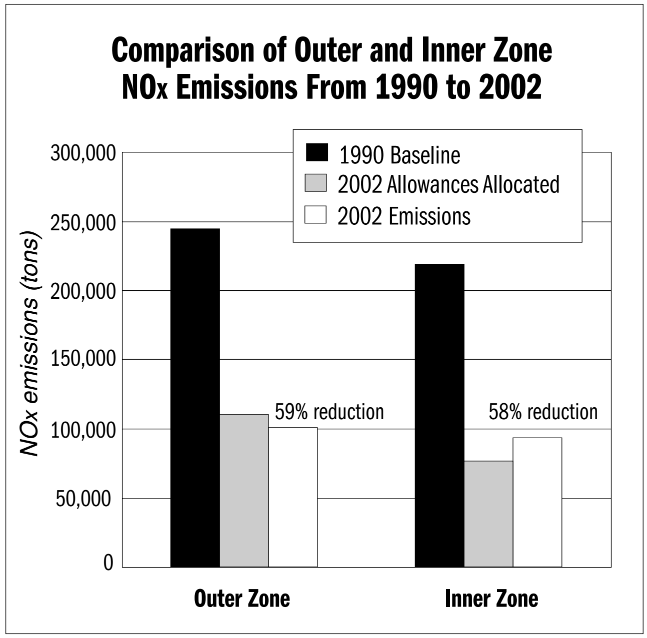
An even more unusual finding concerns the lack of *temporal* shifting of emissions, even on a daily basis, in the OTC NOx cap-and-trade program. The regulation of NOx presents a problem for any regulatory system because NOx formation is episodic and occurs principally on hot summer days. More power is also generated on hot days due to increased demand, potentially causing the most pollution on precisely the worst days. However, it is hard to regulate daily pollutant releases, either through a cap-and-trade program that caps total seasonal tons, or via rate standards, which allow more pollution to occur whenever generation increases.

Notwithstanding these issues, the NOx cap-and-trade program resulted in lowering tons of NOx emissions both in total and on high.-emissions days. Both average and peak emissions during the ozone season declined by roughly the same amount after imposition of the Phase II cap.[65] EPA noted that this finding ''shows that the seasonal budget is reducing daily emissions, even on the days with the highest emissions.''[66] This finding suggests that cap-and-trade programs are possibly more effective than rate-based standards in consistently reducing emissions regardless of short-term changes.

VII. Discrete Emission Reduction Credit Trading

The oldest form of emissions trading is credit trading programs. EPA has allowed market-incentive policies, including open-market emissions or credit trading programs, to be used for criteria pollutants[67] under the Clean Air Act in order to reduce the costs of compliance without sacrificing air quality.[68] Offset programs were established in 1977, and discrete emission reductions

Figure 12



Source: EPA, NOx Budget Program: 1999 - 2002 Progress Report (2003) A BNA Graphic/en425g12

(DER) credit trading programs have been adopted in six states since 1995. DER programs provide flexibility for sources complying with federal emissions standards that do not involve new sources or hazardous pollutants (such as ''reasonably achievable control technology'' or RACT standards) and with sources complying with state emissions standards.

These ''open-market'' systems are established through a certification process in which sources carry out specific projects to create emissions reductions, and then obtain regulatory approval of the tons of reductions created, which can then be traded in the form of emission credits. Although offset programs are frequently used, the DER credit trading programs have resulted in relatively few trades, due in part to the transaction costs involved and regulatory uncertainty.[69]

A. Largest Plants Reduced the Most

A review of the results of six state DER programs and the state procedures involved was recently published by

otcreport.pdf on the Web]; there was also a Northern Zone, but this had little relevance during Phase II, as Maine and Vermont did not participate, and New York and New Hampshire included their northern areas in the Phase II program.

[64] Note that equivalent emissions reductions were made in both zones despite differing allocation of allowances. Sources in the Inner Zone received allowances representing a 65 percent reduction from 1990 levels, whereas Outer Zone sources receive allowances representing only a 55 percent reduction. The states debated whether or nor to impose ratio restrictions on trading between the zones, but eventually decided to allow inter-zonal trading on a one-to-one basis. Id. at 7.

[65] Id. at 8.

[66] Id.

[67] Criteria pollutants are carbon monoxide, lead, NOx, SO_2, volatile organic compounds, and particulate matter.

[68] EPA has established guidelines for the use of such programs as economic incentive mechanisms. See EPA, IMPROVING AIR QUALITY WITH ECONOMIC INCENTIVE PROGRAMS: FINAL GUIDANCE, EPA-452/R-01-001 (January 2001); U.S. EPA, Final Economic Incentive Rules: 59 Fed. Reg. 16,690 (April 7, 1994); U.S. Environmental Protection Agency, Proposed Model Open Market Trading Rule for Ozone Smog Precursors, 60 Fed. Reg. 39,668 (Aug. 3, 1995); EPA, Emissions Trading Policy Statement, 51 Fed. Reg. 43,814 (Dec. 4, 1986) (pt. I).

[69] These programs are reviewed in Environmental Law Institute, *Emission Reduction Credit Trading Systems: An Overview of Recent Results and an Assessment of Best Practices*. Environmental Law Institute (October 2002), available at http://www.elistore.org/reports_detail.asp?ID=10694 on the Web. In general, open market credit trading programs have not generated significant trading opportunities or cost reductions. See generally, Dudek, Daniel & John Palmisano, *Emissions Trading: Why Is This Thoroughbred Hobbled?*, 13 Colum. J. Envtl. L. 217 (1988); Hahn, Robert & Gordon Hester, *Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program*, 6 Yale J. on Reg. 109 (1989).

   ISSN 0013-9211

Figure 13

New Jersey B Generation and Use of NOx DERs by County Ozone Attainment Status (1992-2000)

	Severe (18)	Moderate (2)	Marginal (1)
DERs Generated	32,908 (99%)	295 (1%)	0
DERs Used	1,056 (72%)	403 (28%)	0

Sources: New Jersey OMET Registry for DER credit generation and use by county (July 2001); EPA Air Data B Net Count Report (July 17, 2001) for county 1999 NOx emissions data. A BNA Graphic/en425g13

the Environmental Law Institute.[70] The most concrete conclusion that can be made about emission shifting in DER credit trading programs for NOx is that the generation of credits (equivalent to emission reductions) occurred at the largest plants. The study found that in four of the six states, over 90 percent of credits were generated by fewer than five sources that were typically the largest emitters in the state: 94 percent in Texas, 96 percent in New Jersey and Massachusetts, and 99 percent in New Hampshire. On the other hand, actual credit use, while much less than credit generation, was dispersed among a large number of smaller sources, with typically 10-30 tons being used by a source in one year.

These data confirm a general expectation about trading programs—that they will lead to emission reductions at the largest sources, where the capital cost of pollution abatement strategies or controls can be spread over the largest number of tons and hence lower the per-ton cost of generating a credit.

B. Emissions Shifting at the Area Level

The available regional data for DER programs only allow a limited assessment of emission shifting at the area level for NOx. County-level emissions trading data can be examined in two states, New Jersey and Texas, which give some indication of where emissions were generated and used, and hence allows some assessment of emission shifts.[71] Figures 13 and 14 show that DER programs have tended to reduce emissions in the most polluted counties. To the extent they have shifted emissions at all, the shift has been towards less polluted counties. This pattern indicates that DER programs have cooled hot spots to a limited extent, and led to more evenly dispersed pollution in both states.

New Jersey. Figure 13 shows that 99 percent of DERs in New Jersey were generated in counties with "severe" status for ozone attainment, but 28 percent of the modest DER use was in counties with "moderate" status. This represents a small but slightly beneficial shift of emissions from heavily polluted counties to less polluted counties, reducing rather than increasing emissions concentrations.

Another indication in New Jersey that credit trading did not contribute to hot spots was the simple element of dispersion. Ninety-eight percent of credits were generated in two counties with severe nonattainment status—Hudson and Mercer—whereas credits were used in 10 counties, none of which used more than 28 percent of the total credits used.[72]

Figure 14

Texas B Generation and Use of NOx DERs by County Ozone Attainment Status

	Severe (8 counties)	Serious (5 counties)	Moderate (3 counties)
DERs Generated	38,527 (95%)	0	2,241 (5%)
DERs Used	368 (50%)	368 (50%)	0

Sources: DER credit generation data by county from 1997-2000: Texas DER Registry (version of Oct. 20, 2000); credit use data from Texas Natural Resources Conservation Commission, *Discrete Emissions Credit Banking and Trading Program Audit* (draft, Austin, Texas 2001); county 1999 NOx emissions data from EPA Air Data Net Count Report (July 17, 2001). A BNA Graphic/en425g14

Texas. In Texas, while 38,527 DER credits were generated from 1997 to 2000, only 736 credits were used, making any conclusions tentative. Again, DER generation, equivalent to emissions reductions, is disproportionately higher in severe nonattainment counties where the environmental benefits are greatest; the limited use occurred in both severe and moderate nonattainment counties. Again, DER trading appears to have slightly reduced emissions disproportionately more in severely polluted regions than in less polluted ones (see Figure 14).

VIII. Conclusions

A review of the actual performance of trading programs shows that none of the programs evaluated has resulted in regional shifts of emissions, and all trading programs led to proportionately greater reductions from the larger sources. Overall, the data from the programs reviewed in this report indicate that the effects of trading have been slight but beneficial with regards to geographic hot spots, in the sense of smoothing out emissions concentrations instead of concentrating them, and cooling and not creating hot spots.

A. Trading Has Not Led to Regional Concentrations

At the area level, the principal conclusion that emerges from a review of the data is that trading programs have generally led to consistent behavior in the use of trading mechanisms among regions. In the SO_2 program, the three large regions (Midwest, Northeast and Southeast) behaved very similarly in both phases of

[70] Environmental Law Institute, *Emission Reduction Credit Trading Systems (2002)*, supra note 69.
[71] Analysis derived from id. at 15-18.

[72] Id.

the program, with sources banking allowances to a roughly equal extent during Phase I and emitting slightly over their allowance allocation in the initial years of Phase II. There was also a high degree of consistency among states in the OTC NOx program, even though some states have only a handful of major sources.

In particular, the concern that trading in the SO_2 program could result in ''upwind'' sources in the Midwestern region, disproportionately increasing emissions that affect ''downwind'' areas in the Northeast, did not occur. In fact, due to the number of large plants in the Midwest as well as Title IV's allocation method, there was a disproportionate decrease in emissions in the Midwest, as Midwest sources contributed a disproportionate 60 percent to 80 percent of emissions reductions.[73] The working of the trading program helped to actually reduce emissions in this region with historically high SO_2 levels.

An appropriate conclusion seems to be that in the power sector, any significant group of sources would be expected to behave similarly in a cap-and-trade program, and so negate the idea that there will be emissions shifting. Further research is needed on how many sources need to be included in a trading program in order for it to exhibit such consistency; the evidence from the OTC program at a state level suggests that even a few sources may be enough.

B. Allocation Systems May Help Cut Concentrations

The disproportionate SO_2 emissions reductions in the Midwest appear to be caused largely by the disproportionate reductions at larger plants, but also in part by the method by which allowances were allocated. The SO_2 program allocated allowances to sources based on their past utilization (in Phase II, baseline mmBtu multiplied by 1.2 pounds of SO_2). This method results in dirty plants receiving far fewer allowances in comparison to their past emissions than cleaner plants of a similar size, since allowances are allocated based on past heat input and not on past emissions. This method, therefore, provides a positive incentive for plants with the highest baseline emissions (i.e. those using high-sulfur Midwestern coal) to reduce pollution in areas where it is most needed.[74]

C. In Trading Programs, Largest Sources Reduce Emissions Most

Another striking finding of the results is that emissions trading programs have consistently led to significantly greater emissions reductions at the highest-emitting plants.

In the SO_2 program's Phase II, the largest plants reduced emissions by 73 percent from baseline levels, compared to a 48 percent reduction by the next largest quartile, 41 percent from the third quartile, and only 10 percent from the smallest plants. This is because the economics of installing capital equipment for process changes or controls provides the greatest financial returns when installed in the largest sources, leading to disproportionate emissions reductions at those sources. This attribute of cap-and-trade programs is significant in dispersing and not concentrating emissions, or cooling and not creating hot spots.

D. Summary

Although trading programs do not guarantee reductions at each source, the above data show that they have achieved consistent results between regions, and have also led to proportionately greater reductions at higher-emitting plants. The SO_2 trading program in particular significantly reduced existing hot spots by causing disproportionate reductions in the Midwest. This finding is attributable both to the allocation method used in Title IV and for the tendency in trading programs for the largest sources to reduce emission the most. These findings indicate that cap-and-trade programs similar to those evaluated would not be expected to lead to emissions concentrations or hot spots.

[73] Sources in the eight state Midwestern region (see Figure 6) constituted 42 percent of baseline emissions, but contributed 60 percent of emissions reductions in Phase II; in an expanded 11-state Midwest region (Figure 8), sources comprised 60 percent of baseline emissions and contributed 80 percent of all reductions.

[74] Note, however, that a 10 percent difference in allocation levels to plants in the Inner and Outer zones of the OTC NOx program did not result in any difference in resulting emissions levels. This is in accord with the general trading theory—in perfectly fluid markets, allocations should not make a difference, as emissions reductions should be made where it is most cost-effective to do so. A possible explanation for the discrepancy between the two programs is that the disparity in allocated amounts was simply greater in the SO_2 program, leading to a positive, albeit modest, response. Midwestern sources received 20 percent fewer allowances than those in other states (a 60 percent versus a 40 percent reduction from baseline emissions), twice the difference than in the OTC program. Another possible factor that requires further research is that, given the autarkic response of firms to regulation, allowance allocation systems that differentiate the allocation to sources by region may affect emissions results more if the trading regions segregate firm territories instead of split them. Therefore, allocation systems that split a state in two like the OTC program's Inner and Outer zones may make little difference in firm behavior, as power companies that have plants throughout the state would tend to create a system-wide compliance strategy that would not depend on the allowance allocations to particular sources. Given that firms behave autarkicly, we might expect a more pronounced difference in emissions result if trading programs make different allocations to different states or regions that include all of a firms territory, such as occurred in the SO_2 program.

   ISSN 0013-9211

   ISSN 0013-9211